POTENTIAL SOURCES OF DOMESTIC VEGETABLE TANNINS

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The leather industry of the United States is in urgent need of more adequate supplies of domestic vegetable tanning materials. Twenty years ago this country imported less than half (44 percent) of the total tannin (118,000 tons) used in making leather (2). Today more than 70 percent of our tannin comes from foreign sources.

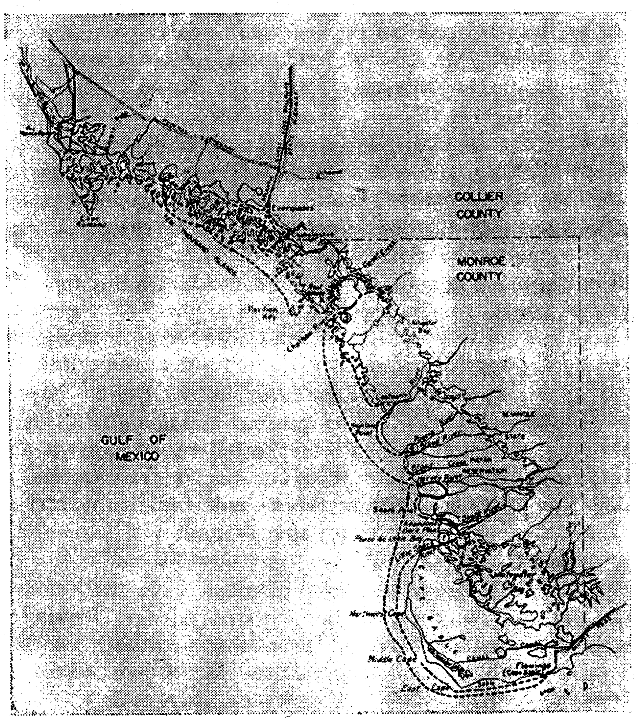

Figure 1. Map of Florida west coast showing routes traveled and numbered areas where mangrove bark samples were collected.

Of the domestic tannins that we produced twenty years ago, about 60 percent came from the wood of the chestnut tree, and the remainder came principally from the barks of oak and hemlock and the leaves of sumac. Today the picture has materially changed, and it is safe to say that more than 90 percent of our domestic tannin comes from chestnut wood. Today practically all the commercial stands of the American chestnut tree have been killed by blight, and our chestnut extract is now being manufactured almost entirely from the dead wood, which at best can last but a few years.

Our need for a largely increased domestic production of vegetable tannins was forcibly brought to our attention during World War II. We were largely dependent upon imported tanning materials for the production of the leather needed for military and civilian use. Tannin shortages occurred as the result of reduced production, submarine sinkings and lack of adequate shipping space. Serious curtailment was threatened in the production of leather, which at that time was rated as the seventh most critical war material. Through careful allocation of available tannins and largely increased deliveries of quebracho, wattle, and other tannins our requirements were met, but the need for increased domestic tannins has not been forgotten.

It has been calculated that from 1937 to 1941 this country used an average of about 113,000 tons of pure 100-percent tannin annually, and of this amount more than 60 percent, or 67,800 tons, was imported. To regain the self-sufficiency in tannin production comparable with that which we had 20 years ago, we should materially increase our present annual production. If our annual consumption is 120,000 tons, we should produce at least 72,000 tons domestically. In addition, potential sources should be developed and available for use in emergency.

To secure and maintain such increased domestic production, new and undeveloped sources of tannin must be used. And, furthermore, these sources must furnish tannin adequate to replace that derived from chestnut wood, when the present dwindling supply is exhausted.

Before potential undeveloped domestic sources of tannin are discussed, some of the investigations that have been completed or are now in progress in this field will be briefly reviewed.

The United States Department of Agriculture has been interested in domestic tanning materials for many years, and has looked with apprehension upon our growing dependence on foreign tannins. It has been

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NORTHWEST CHEMURGIC CONFERENCE

A Northwest Chemurgic Conference will be held in Boise, Idaho, November 18, 19, 1947.

All members in this section are urged to attend this conference. There will be many outstanding speakers of national importance.

Some of the subjects to be discussed are fruit and vegetable byproducts, chemurgic research in the beet sugar industry, chemurgy in Washington, research in Idaho, utilization of nut byproducts, potatoes—industrial uses.

Further information concerning this conference will be released within a few days.

Chemurgic Trading Post

CTP-6191: An organization abroad has the following drug plants available for sale and shipment to this country.

Arnica montana; Artemisia absisthium; A. cacaerulescens; Arctium lappa; Atropa belladonna; Bryonia dioica; Matricaria chamomilla; Chelidonium majus; Conium maculatum; Cochlearia armoraria; Colchicum autumnalis; Carum carvi; Solanum dulcamara; Helleborus niger; Equisetum arvense; Tussilago farfara; Farfara petasites; Aspidium filix mas; Fragaria vesca; Rhamus frangula; Gentiana lutea; Gentiana acaulis; Juniperus communis; Peucedanum; Malva silvestris; Menta virides; Juglans regia; Chrysanthemum cinerariaefolium; Rosa canina; Salvia officinalis; Datura stramonium; and others. Anyone interested in importing these materials can secure additional information from the National Farm Chemurgic Council, Station A, Box 397, Columbus 1, Ohio.

* * *

Governor's Island in Boston harbor was granted to Governor Winthrop on condition that he plant a vineyard or orchard upon it.

Publications Available

REPORT PB34727: Economic Study of German Synthetic Waxes: Has been translated by S. S. Cosman and reviewed by P. F. Dewey. Part A which contains the formulas and methods of production of the I.G. Waxes was in its original German as taken from the Gersthofen Werke of the I.G. Farben A.G. Part B was written in German by the chemists in the Oppau Werke and described the production and application of all I.G. Waxes manufactured there.

The fields of application in which the I.G. Waxes were used changed greatly during the war. The wide use for polishing waxes was reduced as the demands for armament and munitions increased.

This translated report is published in cooperation with the Office of Technical Services of the Department of Commerce. Copies can be obtained from P. F. Dewey, 1516 Spencer Avenue, Wilmette, Illinois. 31 pages, Price $10.00 per copy.

Of Chemurgic Interest

* * * When you're deciding on the color of paint you want used, keep in mind that the more durable paints are dark in color, like red barn paint. Even a little colored pigment adds to the life of the paint. A medium gray or buff-colored paint will last nearly six years, while a white paint of the same quality will need repainting after four years.—*Esso Farm News.* * * *

* * * Damage to fabrics by moths and other insects is prevented for at least a year—the period of test so far—by treating with a modified DDT solution. Material treated by this method retains effective traces of insecticide.—*The Chemical Digest.* * * *

* * * During the first half of 1947 production of coarse papers amounted to 1,443,891 tons, 8.8 percent above the coresponding period of last year. In similar comparison mills operated at about 99 percent and 87 percent of capacity.—*Industry Report Pulp and Paper.*

* * * The grinding process was introduced in the United States in 1866. Now ground wood pulp made from spruce, hemlock and other conifers having little resin, supplies more than three-fourths of the material of all the cheaper printing papers and nearly one-half the materials of the various paper boards.—*Wood.*

* * * A self- adhesive sticker, gummed on both sides, which holds posters, banners, displays, etc. firmly to walls yet permits them to be removed without leaving a trace has been introduced. The sticker needs no moistening and clings to all smooth, clean surfaces.—*Advertiser's Digest.* * * *

* * * Trade names of more than 200 national advertisers have become popular enough to be accepted household words. Among some now listed in Funk and Wagnalls New College Dictionary are Coco-Cola, Nylon, Cellophane, Kleenex, Frigidaire, and Simoniz.—*Type Talks.* * * *

* * *

Americans use more than 70 billion paper bags per year.—Pulp & Paper Bulletin.

realized that the supplies of oak and hemlock barks were becoming scarce and less accessible and that our blight-infested chestnut forests would soon be exhausted as sources of tannin. In view of this situation, a comprehensive, long-time cooperative program for the development of domestic tanning materials was undertaken several years ago by the Bureau of Agricultural Chemistry and Engineering*, the Bureau of Plant Industry**, and the Soil Conservation Service.

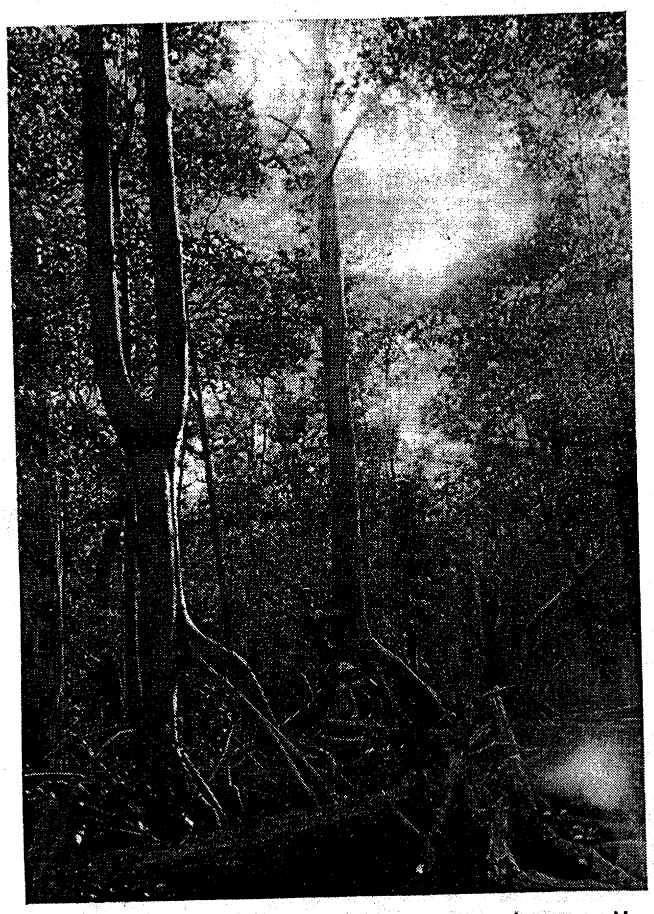

Figure II. Estuary type red mangrove from sampling area No. 4, near mouth of Broad River.

This program of work has been described by Frey and Sievers (1). Among other things, they pointed out that:

(1) more specific information was needed on unexplored tannin-bearing plants;

(2) Although cultivation of tannin crops was successfully practiced in some foreign countries, it had not been undertaken in the United States;

(3) before cultivation of tannin crops could be begun, much information pertaining to cultural, economic, geographic, climatic, and agricultural conditions must be obtained;

Figure III. Typical scrub red and black mangrove, south of Homestead, Florida.

(4) plants selected for study should preferably produce their tannin concentrated in roots, leaves, or fruit and should be suitable for handling as tannin crops;

(5) although the studies already started in this program dealt primarily with sumac and canaigre, other promising materials might be included as the program developed.

A comprehensive study of the bark of the western hemlock, *Tsuga heterophylla*, (Ref.) Sarg., as a potential source of tannin was conducted by Smoot and Frey, and the results were reported in 1937 (2) in United States Department of Agriculture Technical Bulletin No. 566. The average tannin content of the bark of the western hemlock was 15.5 percent on a moisture-free basis. Woods-peeled, well-cured bark was considered the most desirable. It was found that bark from logs that had been floated in salt water was not suitable for extraction because of its contamination with sodium chloride, but bark from logs out of fresh-water mill ponds could be used if the logs had not been left in water too long. The tannin content of such bark should not be below 14.5 percent. Artificial drying of the bark was studied, also the preparation of tanning extracts. The following excerpts from the summary of this bulletin are of interest:

"Successful utilization of the bark hinges on a rather narrow working margin of profit. . . Quick returns and large profits are not to be expected. On the other hand, in view of the tremendous quantities of bark and our large annual consumption of tannin . . . there appears to be an opportunity of establishing a permanent business of large volume.

"Successful salvage of the bark as tanning extracts would increase our taxable wealth . . . give employment to domestic labor, decrease our dependence upon foreign materials, thereby adding to our national security in emergency, and increase our exportations in normal times."

Frey and Clarke (3) have investigated the tannin content of the bark of Sitka spruce, *Picea sitchensis* (Bong.) Carr. Thirty-one samples collected at various places in

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*Now the Bureau of Agricultural and Industrial Chemistry.
**Now the Bureau of Plant Industry, Soils, and Agricultural Engineering.

Washington and Oregon contained an average of 24.1 percent tannin on a moisture-free basis. The thickness of the bark ranged from 1/16 to 1/2 inch and averaged about 3/16 of an inch. In view of the size of the annual cut and the low yields of bark per tree, it probably could be utilized successfully only as a supplement to hemlock bark produced in the same area.

Sands (4) has reported on the potential supply of unused hemlock bark in the Lake States. Consumption of hemlock bark decreased from 77,600 to 8,800 cords in 17 years. The available potential supply in 1945 was reported as being about 200,000 cords. Sands suggested that peeling costs might be reduced and pointed out that the establishment of an extract plant and production of extract in the upper peninsula of Michigan would reduce shipping costs, which represented about one-quarter of the cost of the tannin.

Alfred Russell (5) and his co-workers have studied the tannin content of a large number of materials from the southeastern part of the United States. This results have been reported in eight papers under the general title "Natural Tanning Materials of the Southeastern United States."

From four areas, designated as "Tropical and Subtropical," "Coastal Plain," "Piedmont Section," and "Mountain Section," samples were collected representing 45, 39, 66, and 35 species, respectively. Both barks and woods were analyzed for tannin and, in many instances, extracts were prepared and tanning tests run.

Of 185 samples studied, only 7 of the woods contained tannin ranging as high as 6.9 to 12.3 percent. In 183 samples the associated barks were higher in tannin than the wood. The tannin contents of 41 of the barks ranged from 8.2 to 25.5 percent, but only 5 contained tannin above 20 percent. These were buttonwood, Pigeon plum, dilly, sea grape, and red mangrove. Russell gave no information as to thickness of bark, yields of bark per tree, available stands, accessibility, or rate of growth. Aside from the well-known species, such as mangrove, oak, and chestnut, there is a question whether any of these species are available in sufficient quantities to justify their use for extract manufacture. Their development by cultivation would require years of experimentation.

Tara, *Caesalpinia spinosa* (Mol.) Kuntze, has been imported rather extensively during the last few years as a replacement for Sicilian sumac, which was not available during the war. Some difficulty was experienced in leaching the pods because of the gum in the seeds. Rogers and Beebe (6) found that the powdery and fibrous materials from the pods contained as high as 67 and 56 percent of tannin, respectively. Although not

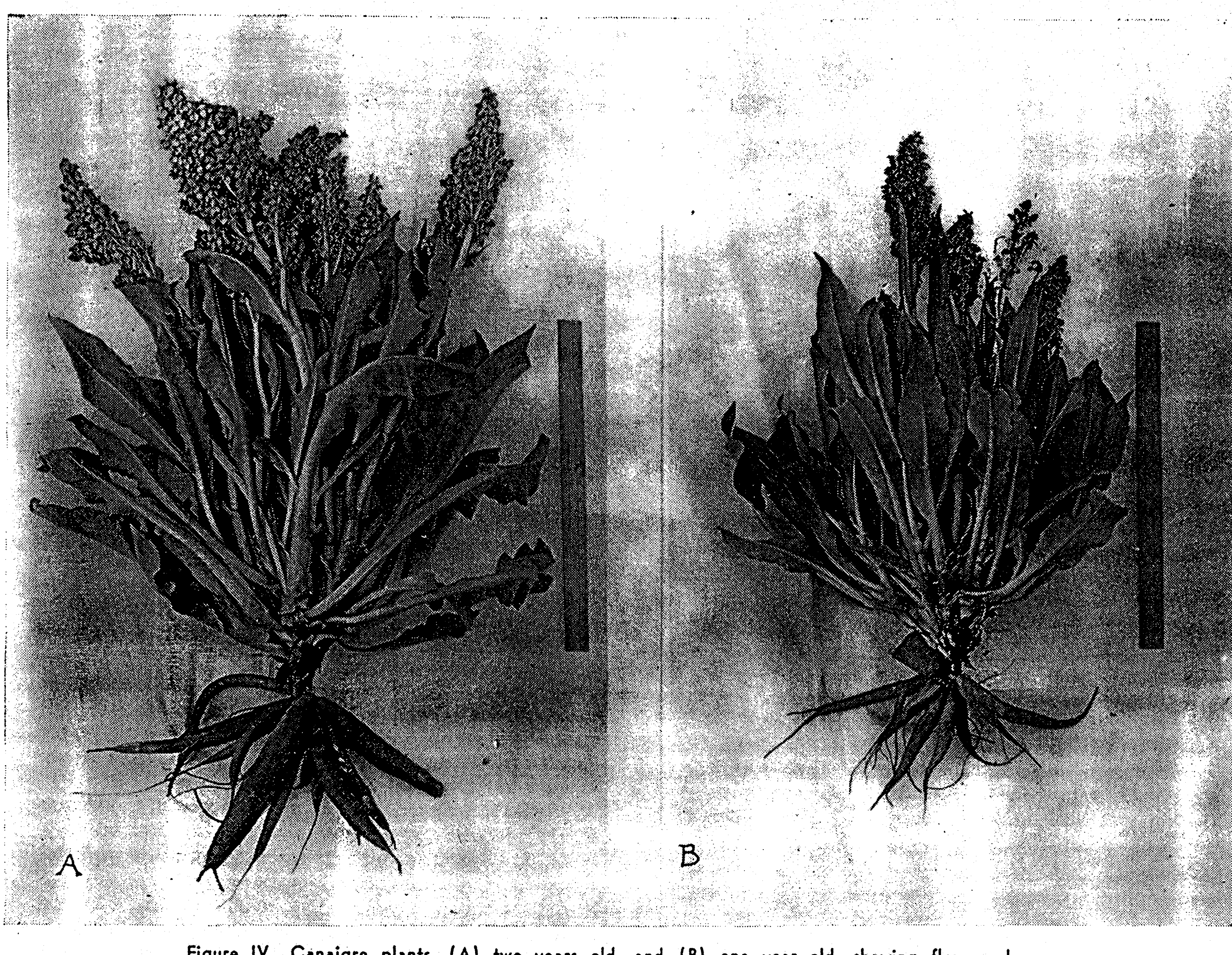

Figure IV. Canaigre plants, (A) two years old, and (B) one year old, showing flowers, leaves, and roots. The parent root-crown used for planting can be seen among the roots of the one-year old plant at the right.

equal in every respect to Sicilian sumac for tanning, tara served advantageously during the war as a partial replacement for sumac. It produces an almost white leather, one which is much lighter in color than sumac tanned leather. Tara is of particular interest because it has grown successfully in some areas in California. Plantings made at a field station of the Department of Agriculture at Chula Vista, California about 20 years ago have thrived with very little care. Pods collected recently from these trees and analyzed at the Eastern

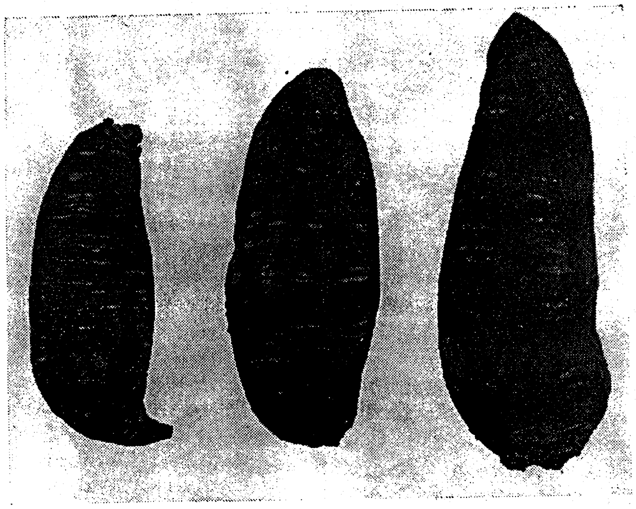

Figure V. Canaigre roots. The middle root is 3 x 6 inches.

Regional Research Laboratory showed 70.3 and 62.9 percent tannin, respectively, in the powdery and fibrous portions. If a tannin of the pyrogallol or hydrolysable type is sought for the tannage of light-weight, light-colored leathers, tara might be grown in California to meet this need. However, the cultural and economic aspects of such production would require investigation.

Wattle, another foreign tannin, has an established reputation in the leather industry. Some of these trees introduced into this country more than 50 years ago are now growing in California. Kegley (7) under the title "California Launches Wattle Industry" reports a program in California for the large-scale growing of wattle, *Acacia decurrens* Willd. varieties normalis and mollis, for the production of tannin and pulpwood. This program, under the supervision of the Drug and Oil Plant Division of the State Department of Education, proposes to plant 375,000 acres of black wattle during a period of 10 years, the combined planting at the end of 20 years possibly to amount to 1,000,000 acres. It is planned that, after 7 to 10 years, when the first planting of trees will reach maturity, 37,500 acres of wattle will mature each year and will yield 325,600 tons of wattle bark. This is an ambitious program which, if successfully carried out, would yield a tonnage of domestically produced tannin greater than our average annual consumption between 1937 and 1941.

On the basis of the author's estimated cost of $365.97 per matured and harvested acre, this project would entail an investment for 37,500 acres at the end of 10 years of more than $13,700,000. With continued annual plantings during the intervening 9 years calculated at the same proportional rate, there would be at the end of the first 10 years a total investment of more than $75,000,000. This amount would all be invested before any financial returns could be realized and before the economical soundness of commercial wattle production in this country had been established.

Several tannin-containing materials native to Florida that might be made immediately available have been studied and reported by May and Frahm (8). These included saw and cabbage palmetto, red and black mangrove, six species of scrub oaks, dwarf sumac, and slash pine. From the standpoint of tannin content and purity of extract, red mangrove bark with 24 percent tannin, dwarf sumac leaves with 24.4 percent tannin, and some of the scrub oak barks, with tannin ranging from 9 to 12.6 percent, are of interest.

The authors directed particular attention to scrub oak barks. They pointed out that there are approximately 5,000 square miles of scrub oak forest in Florida and that turkey oak, *Quercus laevis* Walt., is the predominating species.

From the foregoing, it is evident that several domestic materials might be developed sufficiently to justify their serious consideration as potential commercial sources of tannin. Six materials will be considered and discussed in some detail under two subdivisions. The first will include the barks of the western and eastern hemlocks, red mangrove and scrub oaks: the second will consider potential tannin supplies obtained from sumac leaves and canaigre roots produced as annual farm crops.

Potential Tannin Supplies from Annual Crops

Western Hemlock Bark: Western hemlock bark is obtained from the tree known botanically as *Tsuga heterophylla* (Ref.) Sarg. It grows in an area along the Pacific coast from Alaska to northern California and inland to Idaho and Montana. Although Smoot and Frey (2) pointed out that this bark contains about 15 percent tannin and has possibilities for development, no major commercial processing of western hemlock bark into tanning extract has been undertaken.

A survey by the Pacific Northwest Forest and Range Experiment Station (9) showed that the consumption of western hemlock sawlogs in 1941 in western Washington and Oregon was 1,375,000,000 board feet (log scale). More than half these logs were floated in salt water and a large portion of the remainder in fresh water. This resulted in a partial leaching of the bark and a loss of about 50 percent of the natural tannins. About half the bark was contaminated with salt, and all the floated bark was wet and low in tannin.

It has been estimated that each 4,350 board feet* (log scale) of western hemlock sawlogs will produce 1 ton of air-dry bark. If it is assumed that air-dry bark contains 15 percent moisture, that the moisture-free bark contains 15 percent tannin, and that an 80 percent leaching efficiency is possible, then unfloated bark from 1,375,000,000 board feet of logs should

*Various values have been given for conversion of board feet, log scale, to cords of air-dry (15% moisture) bark. These range from 2,400 to 5,000 board feet per cord. J. Elton Lodewick, in charge of Forest Products of the Pacific Northwest Forest and Range Experiment Station of the United States Department of Agriculture, reported the following conversion factors to the Director, S. N. Wychoff, in May 1942:

1 cord (air-dry - 15-20% moisture) bark weight 2,300 pounds (1.15 T)

1 ton air-dry bark is yielded from 4,350 board feet - log scale of logs spud peeled.

1 ton air dry bark is yielded from 1,470 board feet - log scale of large logs peeled hydraulically.

yield about 35,000 tons of 100 percent tannin—an amount equivalent to nearly one-fourth of our 1941 tannin consumption. If all the bark were floated, less than half this amount of tannin could be recovered, the quality of extract produced would be lowered, and the cost of extract production increased.

In the past, most of the bark at pulp mills has been removed from floated logs by mechanical barkers. This procedure gave a bark product sometimes containing as much as 50-60 percent wood. During recent years hydraulic barkers have been developed, which remove the bark effectively and take off relatively little wood. Because of high labor costs the pulp and timber industries have never considered it economically feasible to hand-peel hemlock logs in the woods or on peeling docks. As a result, relatively little hemlock bark of the quality best suited for leaching and extract preparation has been produced. It is understood, however, that one concern is now hauling appreciable quantities of their logs to the mills by truck. These are barked hydraulically after only a short immersion in fresh water in the mill pond. This company proposes to use the bark for leaching and the preparation of tanning extract. It would appear that such a procedure might prove successful, making possible the production of a high quality tanning extract with a minimum loss of tannin.

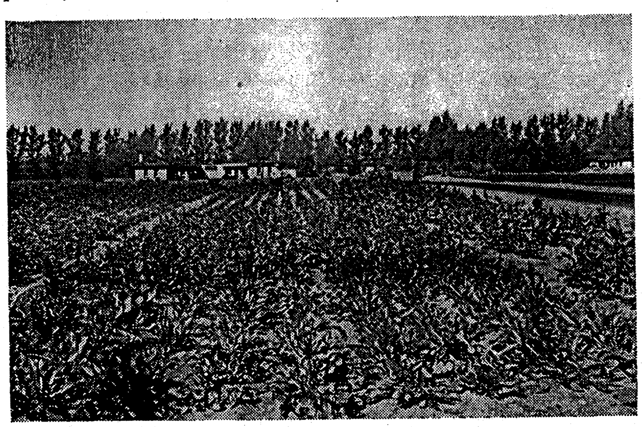

Figure VI. Irrigated field of canaigre in New Mexico.

On the basis of the 1941 survey (9) and the assumption that similar amounts of hemlock logs could be made available annually, about 35,000 tons of 100 percent western hemlock tannin should be potentially available each year, provided that the bark were removed from logs before they had been floated. The salvaging of large quantities of hemlock bark might be accomplished by woods—or deck-peeling of the logs or by hydraulic barking of truck or barge-transported logs that had been subjected to only brief wetting in mill ponds.

In considering economic phases of the commercial production of tanning extracts from western bark, labor and the high transportation costs involved in shipping tanning extracts from the West Coast to the tanning industry in the East must not be overlooked. They are two of the major factors in determining the economic feasibility of producing tanning extracts from western hemlock bark.

Eastern Hemlock Bark: Use of the bark of eastern hemlock, *Tsuga canadensis* (L.) Carr., as a source of tannin has declined materially in recent years. This is probably due to the increased costs in getting the bark from the more remote and inaccessible areas, the closing of some tanneries, and a shift to more easily obtained tanning extracts.

A report prepared in 1943 by the Forest Service in cooperation with the War Production Board (10) indicated that the maximum possible production of hemlock bark in the Lake States region in 1943 would be 65,000 cords.

A similar report covering the Appalachian Region, prepared in 1943 by the Forest Service, (11), showed that enough hemlock timber was cut in 1941 and 1942 to produce 50,000 tons of bark each year. The amount actually peeled, however, was only 30,000-35,000 tons. It was estimated that an equal number of tons of bark could be produced in 1943.

Sands (4)* has indicated that much hemlock timber is cut in the Lake States from which the bark is not salvaged. He stated that in 1944 nearly 200 million board feet of hemlock lumber was manufactured, and 385,000 cords of hemlock pulpwood were cut. Allowing 1 cord of bark for each 2,000 board feet, this would indicate a potential bark supply from this area of nearly 200,000 cords.

Red Mangrove Bark: Red mangrove, (American Mangrove) *Rhizophora mangle* L., is found growing rather extensively on shores and keys of the Florida peninsula. During World War II while investigations were being conducted to locate additional and quickly available supplies of tannins, a preliminary survey of Florida mangroves was made for the War Department by the United States Forest Service under the leadership of Mark M. Lehrbas. The East and West coasts, keys, and estuaries were traveled by boat or automobile. Seven representative bark samples, collected from each of the four principal areas, were examined for tannin at the Eastern Regional Research Laboratory. Rogers and Luvisi (12) have reported the results of this study. They showed that the average tannin contents and purities of the barks from the four areas were as follows:

Area	Type	Tannin Constant %	Purity
Shark River	estuary	32.2	68.2
Tiger Key	key	34.8	70.7
Chatham River Key	key	30.6	66.2
Broad River	estuary	28.2	63.9
Average		31.5	67.3

It will be noted that the average tannin contents ranged from 28.2 to 34.8 percent and that the general average was 31.5 percent tannin, with an average purity of 67.3. These figures indicate that, as regards tannin content and purity, Florida mangrove bark would be an acceptable source of tanning.

The Forest Service's preliminary survey (Fig. I) has shown that the largest and most promising area for collection is the one that produces the estuary type of bark (Fig. II). This area lies along the west cost from Little Shark River to Rogers River. It has been estimated that this area contains about 30,000 acres, with a potential total production of 25,000 to 26,000 cords

*In a private communication dated October 23, 1946, Sands stated that the average tannin content of hemlock bark from upper Michigan and northern Wisconsin is about 10 percent. However, samples of hemlock bark collected near Newberry and Watersmeet, Michigan, in 1944 and analyzed at the Eastern Regional Research Laboratory showed, on a moisture-free basis, tannin ranging from 12.3 to 13.9 percent.

of mangrove bark. From this it should be possible to produce about 5,000 tons of 100-percent tannin. If production were spread over a period of 5 years, it would be sufficient to operate an extract plant with a yearly capacity of 2,000 tons of solid mangrove extract.

On the basis of this preliminary survey, the prospect for the development of Florida mangrove bark as a commercial source of tannin does not appear very promising. The reasons are the high cost of labor, the difficulties in getting the bark out of the swamps, and the apparently limited amounts of bark available. There are, however, large areas of scrub mangrove (Fig. III) that probably were not included in the estimated available supplies. If the bark of this material has an acceptable tannin content and if the small stems can be economically chipped and the bark and wood separated mechanically, a greatly increased supply of mangrove bark may be obtained.

In any event, a more accurate and detailed survey of the potential mangrove bark supplies available in this and other Florida areas should be made before serious consideration can be given to the commercial development of this material as a domestic source of tannin.

Scrub Oak Barks: The scrub oaks native to the southeastern part of the United States probably include 20 or more species. Of these the two most abundant are blackjack oak, *Quercus marilandica* Muenchh., and turkey oak, *Quercus Laevis* Walt. The latter was particularly noted by May and Frahm (8) as a possibility for development as a source of tannin. A large representative sample of bark analyzed at the Eastern Regional Research Laboratory contained 10.1 percent tannin (moisture-free basis). The bark was leached without difficulty in a battery of leaches, and the leach liquors were concentrated by vacuum evaporation and drum-drying to a powdered tanning extract which contained 61.2 percent tannin and had a purity of 63.7.

On the basis of these results, a more extended study involving pilot-scale tests seemed desirable. A cooperative program was accordingly inaugurated with the Florida Engineering and Industrial Experiment Station. It involved a more careful survey of seven areas to determine available supplies, the collection and analysis of samples to accurately establish tannin contents, studies of bark yields and barking procedures that would be applicable to trees of small diameter, and the collection and drying of a tonnage of sufficient bark for pilot-scale extract preparation and tanning tests.

Considerable progress has been made in this work. Ten samples of bark were collected in each of the seven areas studied. In one area, all the trees were bluejack oak, *Quercus cinerea* Michx., and the average tannin content of the bark was 6.7 percent. In the other six areas, all the trees sampled were turkey oak. The average tannin content of the bark from these six areas ranged from 9.9 to 11.3 percent, the overall average being 10.5 percent. These results indicate that bark of turkey oak, on the basis of its tannin content and purity, should be suitable for the production of tanning extract. A report of this investigation is being prepared for publication.

Calderwood and May, at the Florida Engineering and Industrial Experiment Station, obtained considerable field and processing data on scrub oak bark. The results of their studies have been assembled in three papers under the following titles: "Scrub Oak Measuration" (14), "Scrub Oak as a Potential Replacement for Chestnut," (15), and "Florida Scrub Oak—New Source of Vegetable Tannin." (13).

Because of the high labor costs, hand-peeling tan bark from the logs is not an acceptable procedure for extremely small trees of the scrub oak type. Appreciating this fact, Calderwood has developed a mechanical process by which the entire tree may be utilized. The trunk, limbs and branches are chipped in a hog, and the mixture of wood and bark chips is separated

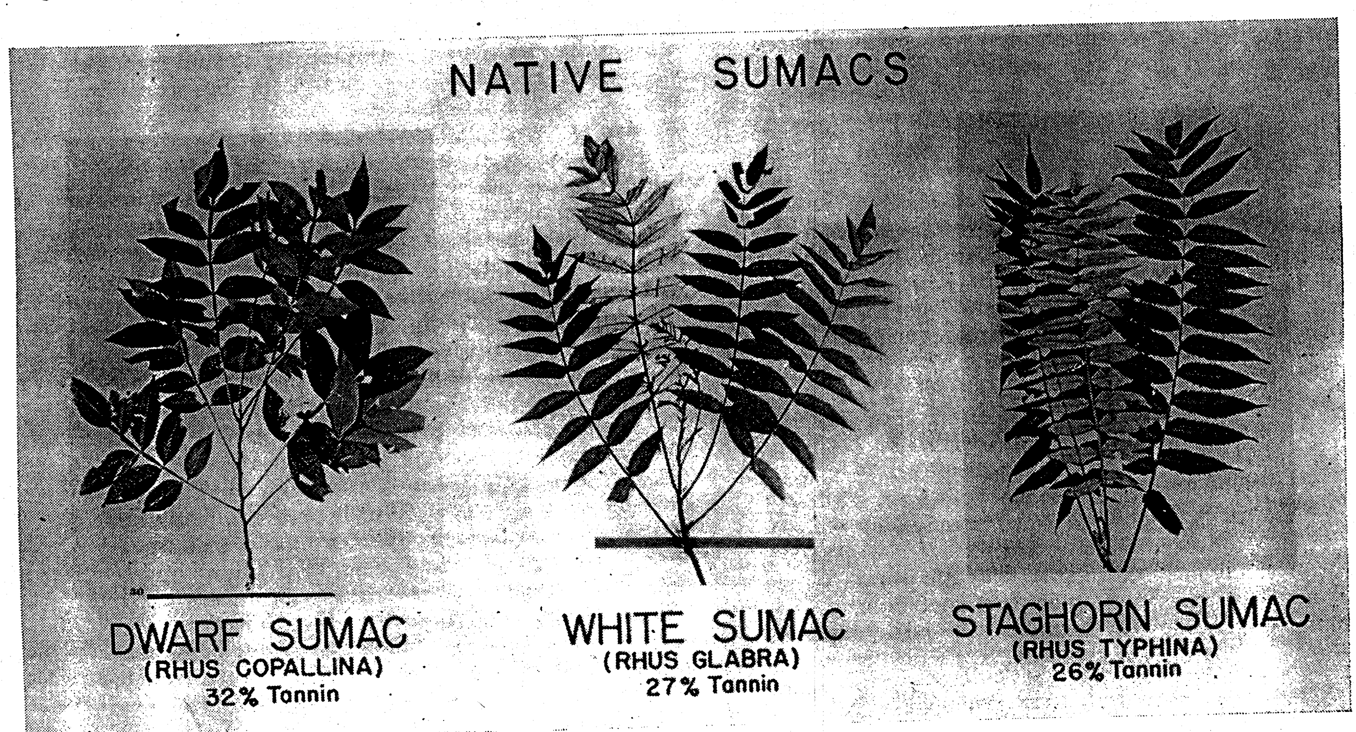

Figure VII. Leaves of three important domestic sumac.

mechanically in a commercially available air-float separator. The bark is dried by heat to a moisture content of about 15 percent to prevent spoilage while stored in bulk. Use of the wood chips for the production of wood pulp is under consideration. By this process, bark can be successfully separated from wood in Florida at any season of the year, and utilization of the entire tree would represent a marked saving in both bark and wood.

New schedules for computing cord yields, developed specially for use with small trees, including limbs and branches, have been employed in calculating average yields. They indicate that these lands in Florida where oaks have taken possession will yield, on that basis of 10 cords per acre, approximately 1.5 million tons of bark (15% moisture) and 8 million tons of undried wood. The recoverable tannin from 1.5 million tons of scrub oak bark probably will not exceed 102,000 tons of 100-percent tannin, an amount materially less than the average annual consumption of tannin in the United States. If spread over 20 years, to give an opportunity for trees to grow and sustain continuous extract plant operation, it would permit an annual production of 5,100 tons of tannin, or an amount approximately equal to the production of two extract plants, each with a daily capacity of 160 barrels of 25-percent tannin extract.

If these processing methods for handling scrub oak bark prove to be economically feasible, there are other areas, in Texas, North and South Carolina, Georgia, and Tennessee, where scrub oaks could be utilized, thus considerably augmenting the potential amount of tannin obtainable from this source.

Potential Tannin Supplies from Barks

When tannins are obtained from barks or woods, the trees are destroyed, and long periods of time, from 8 to 50 years, or even more, are required to grow replacements. For this reason, the development of new home tannin supplies by reforestation would prove far too time-consuming to meet the need. Aside from utilization of barks now available, the most promising approach to this problem appears to be one involving the domestic production of tannin by growing annual tannin crops. Several materials may prove satisfactory for this purpose, but attention is now being devoted particularly to two domestic plants, namely, canaigre and sumac. These can be grown as annual crops and as such may be used to replace crops now produced in surplus quantities or, in the case of sumac, may be used on land that is not suited for growing cultivated crops because of erosion difficulties.

The domestic production of tannin from cultivated crops has several advantages. Quick returns are possible. Amounts produced can be increased or decreased to meet changing demands. By-products can be used to reduce the cost of tannin to the consumer, and new farm crops would be provided for rotation or replacement of crops now producing surpluses. Increased domestic production of vegetable tannins would reduce this country's dependence upon foreign tannins.

Canaigre Development Studies: Investigations with the object of the development of canaigre as a source of tannin are now being conducted (16) as a cooperative project. The Bureau of Plant Industry, Soils and Agricultural Engineering is largely responsible for the field planting, cultivation and harvesting phases of the work, and the Eastern Regional Research Laboratory of the Bureau of Agricultural and Industrial Chemistry is working on laboratory development, processing, and tanning problems.

Canaigre, *Rumex hymenosepalus* Torr., is native to the southwestern part of the United States and the northern part of Mexico (Fig. IV). Root crowns planted in the fall produce new mature tuberous roots (Fig. V) the following May or June. Under favorable conditions, yields of as much as 10 tons of roots per acre can be obtained. When moisture-free, the roots contain from 20 to 35 percent tannin, from 25 to 40 percent starch, and from 10 to 20 percent sugars.

Field Studies: In field studies extending over several years, valuable information on production problems has been acquired. Some of the important factors studied were propagation methods in which seed and root crowns were used, trends in tannin content and yields in successive years, effect of fertilization, water requirements, selection and development of high-tannin strains, adaptability of different locations, methods of planting and harvesting, and the field washing, shredding and drying of roots. (17)

Although no large-scale field tests on the production of canaigre have yet been completed, small experimental plots (Fig. VI) indicate that, under favorable conditions, it should be possible to produce an average of about 10 tons of fresh roots per acre per year, which in turn should yield an average of 1,000 pounds of recoverable 100-percent tannin. Varying industrial needs for tannin could be met by carying the annual tannin crop.

Extraction of Tannin: Because of the starch, the tannin cannot be effectively extracted from canaigre roots by the hot-water leaching procedures normally used for extraction of tannin from barks or woods. To overcome this difficulty, a process (18), (19) has been developed in the laboratory for the effective extraction of the tannin. This involves pulping the shredded, dried roots with water at about 45°C., mixing, and separating the liquor by centrifugal filtration. By operation of the system as a countercurrent extraction, fairly concentrated liquors are obtained.

Producing High-Purity Liquors by Fermentation: The sugars in canaigre are extracted with the tannin, resulting in low-purity tannin liquors, that is, liquors in which the nontannins considerably exceed the tannins. This difficulty has been overcome by removing the sugars by fermentation. (20) Since the bacteria normally used to ferment sugars do not act effectively in the presence of tannin, other types, isolated from canaigre roots and soils, were used. By fermentation with these as yet unidentified bacteria, a large part of the sugars has been successfully removed and high-purity canaigre liquors have been prepared.

Preparation of Tanning Extract: Preparation of powdered tannin extracts from high-purity tannin liquors does not present a difficult problem. The liquors are filtered or settled, if necessary, and then concentrated by vacuum evaporation to thick liquid extracts, which are subsequently converted to powdered extracts by vacuum drum drying. By this procedure, high-quality canaigre tanning extracts have been prepared on a laboratory scale. These contained more than 62 percent tannin, had a purity of 68, and compared favorably with commercial extracts.

Experimental Tanning Tests: Small scale tanning tests in which canaigre extract was used for tanning heavy leather of the sole leather type have been conducted in the laboratory, and tests in which powdered canaigre root was used for the direct tannage of sheepskins and the pretannage of pickled cowhides have been made in commercial tanneries. All these tests gave promising results, indicating a potentially successful future for canaigre as a tanning agent. Before this goal can be attained, however, further studies are essential.

Pilot and Semicommercial Tests Needed: To establish the best and most economical methods of growing and harvesting canaigre and to determine average large scale production costs, canaigre must be grown experimentally on a semicommercial scale. Pilot-scale processing of roots for evaluation of processing methods and costs must be conducted, and semicommercial lots of extract must be prepared and tested in regular tannery operations. A part of the total production costs of canaigre can probably be borne by utilization of by-products.

Development and Utilization of By-Products: Work on the development of by-products from canaigre roots has not yet been started, but this phase of the studies will be given special consideration. It is certain that suitable processing of the sugar, starch, and spent pulp materials by fermentation or by other methods will yield products of considerable value. These should aid in lowering the cost of canaigre tanning extract.

Sumac Development Studies: Development of domestic sumac as a source of tannin is also being studied at the Eastern Regional Research Laboratory as a cooperative project with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Soil Conservation Service.

Domestic sumac and an imported product, Sicilian sumac, *Rhus coriaria* L., have been used for many years for tanning light leathers and making tanning extracts. Sicilian sumac, however, has always been preferred by tanners because it has given better color and "feel" to leather and possessed a higher tannin content than domestic sumac as ordinarily supplied. It has long been felt that much of the difference might be overcome by proper gathering, curing, and handling methods.

Three species of sumac are abundant in the eastern part of the United States (Fig. VII). These species, dwarf sumac, *Rhus copallina* L., white sumac, *Rhus glabra* L. and staghorn sumac, *Rhus typhina,* Torner have average tannin contents of 32, 27, and 26 percent, respectively. To determine the relative value of these species, large lots of leaves of each were gathered in 1944, properly cured, ground, and supplied to a cooperating tanner, who used them for tanning 330 dozen sheepskins. These tanning tests included tannages with Sicilian sumac for comparison (21). All three sumac made leathers of satisfactory commercial quality, although dwarf sumac reacted more like Sicilian in some respects and had the highest average tannin content.

A survey of about 12,000 square miles in southern Virginia in 1942 (22) disclosed large amounts of each of the three common sumac species. The quantity of sumac found in the area alone was at least ten times the total annual prewar consumption of sumac in the United States.

In addition to being a potential source of tannin, the native sumacs have shallow spreading root systems which make the plants ideal for preventing soil erosion by rain. They should thus make suitable crops for land that is too easily eroded to permit its use for cultivated crops. Trials (23) have shown that it would be possible to grow under cultivation any one of the three species mentioned above (Fig. VIII).

Studies are now in progress which have as their objectives the determination of factors that affect sumac quality and the development of methods for handling that will ensure a product of highest quality. For example, Clarke and Hopp (24) found that the leaves should be dried rapidly after gathering, because decomposition products form during slow drying that result in dark leather. Luvisi and Clarke (25) have reported data which show that temperature must be low and time of leaching short if a high-quality sumac extract is to be produced. Boyd (26), (27), (28) has described a method for treating sumac seed with sulfuric acid to improve germination, and has reported a study of the root systems and the value of sumac for controlling erosion and also the tannin contents of four species collected in Iowa.

Machinery and methods used in Iowa for experimental harvesting, drying, separating stems from leaves, and baling sumac have been described by Barger and Aikman (29).

Figure VIII. Experimental plot of dwarf sumac, Rhus copallina L. grown in one year from seed, showing effect of cutting at different dates during the late summer of the first growth season upon second season's growth.

In view of the results already obtained, the possibilities seem good for the development of domestic sumac as a tannin crop by the cultivation of high tannin strains of some of the species studied.

Other Potential Sources of Tannin

Although recovery of tannin from pine bark has not been discussed in this paper, this potential source has not been overlooked. Large quantities of this bark are produced and might be salvaged. Our analyses of a small number of samples of longleaf pine bark have shown tannin contents ranging from 6.4 to 11.6 percent and averaging 9.2 percent. Because of its rather low tannin content and the problems involved in its utilization, considerable research will be required before the feasibility of using pine bark can be established.

Studies are also in progress on the recovery of tannin from pecan shells. From 25 to 40 percent tannin has been found in the inner liner of the pecan shell. The hard outer shell has little tannin. Because of the comparatively small amount of this material available, it has not been discussed in this paper.

Another material worthy of study as a potential tannin crop is badan, *Bergenia crassifolia* F. Its leaves are reported to contain about 20 percent tannin, (on a moisture free basis). It is under cultivation in Russia and Czechoslovakia for its tannin. It also yields hydroquinone.

Considerable progress has been made in the development of synthetic tannins. One material in particular, which in tanning properties resembles vegetable tannins, is now in commercial production. Undoubtedly it will establish a place for itself as soon as its price can be lowered to compare with those of the available vegetable tannins.

CONCLUSIONS

In summarizing the situation regarding potential sources of domestic tannins, the fact must not be overlooked that accurate information on potential supplies is not available. Conclusions can only be based upon surveys and estimates. All sources have not been covered in this paper. It is believed, however, that consideration has been given to the most important available materials and to those having the most promise of development.

On the basis of the most optimistic estimates, it appears that the following quantities of 100-percent tannin might be recovered annually:

	Tons
From unfloated western hemlock bark,	about 35,000
From Lake States hemlock bark,	about 17,000
From Appalachian hemlock bark,	about 4,080
From Florida scrub oak bark (for a period of 20 years)	about 5,100
From Florida mangrove bark (for a period of 5 years)	about 1,000
From Florida scrub oak bark	
Total	62,180

It must be remembered that these figures are based in all cases on the most favorable estimates. Recovery of these amounts of tannin can be accomplished only by radical changes in present logging and lumbering practices. If in 1942 improved economical methods had made it possible to salvage 50 percent of these potentially available bark tannins, or 30,000 tons of tannin, and this amount had been added to our 1942 domestic production and deducted from the quantity imported for that year, we would have produced slightly more than 50 percent of the tannin that we used. This increase in domestic production, however, would have been less than the normal annual production from chestnut wood. It would, therefore, make no provision for replacing the continually decreasing supplies of chestnut tannin.

From the foregoing, it is evident that the development of new sources of vegetable tannins is imperative if this country is to produce even half the vegetable tannin that it uses. To meet this situation, the two most promising fields of endeavor appear to lie in (1) increased utilization of available tannins in barks and (2) development and production of annual tannin crops.

ACKNOWLEDGMENTS

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CHEMURGIC REPRINT SERIES

The National Farm Chemurgic Council makes available throughout the year a great number of publications. The following list is composed of outstanding articles contained in *The Chemurgic Digest*. The demand for extra copies of these stories has been large enough to necessitate a reprint series, available at approximate cost.

Those desiring copies address their request to the Publications Division, National Farm Chemurgic Council, Station A, 397, Columbus 1, Ohio.

34. The Utilitization of Forest Waste by Harry G. Uhl, 25 cents.

35. Postwar Prospects of the Fertilizer Industry, by Charles J. Brand, 50 cents.

36. The Use of Guar in Paper Manufacture, by Ben W. Rowland, 50 cents.

37. Starch Sponge, by M. M. MacMasters and R. H. Blau, 25 cents.

38. Chemical Soil Tests and the Farmer, by Frank La Motte, 25 cents.

39. The Tung Oil Industry: Growth and Prospects, by Earle L. Rauber, 50 cents

40. Possibilities for Industrial Uses of Grain Sorghum, by R. E. Karper, 50 cents.

41. Experiments with Sesame, by A. F. Sievers, 50 cents.

42. Chlorophyll, by Robert S. Aries, 50 cents.

43. New Horizons in Animal Nutrition and Farm Chemurgy, by Dr. H. J. Prebluda, 25 cents.

44. Seaweed Products and Their Uses in America, by C. K. Tseng, 50 cents.

45. Industrial Uses for Peanuts and Peanut Products, by C. L. Wrenshall, 50 cents.

46. A Review of the Experimental Work on Castor Beans in the United States, by Dr. W. L. Burlison and Dr. R. O. Weibel, 50 cents.

47. Some Rothamsted Contributions to Agricultural Chemistry, by W. G. Ogg and Dr. Hugh Nicol, 25 cents.

48. Charcoal Production, by Edgar L. Heermance, 25 cents.

49. The Future of Aspen in the Lake States by Zigmund A. Zazada and W. A. Kluender, 25 cents.

50. Chemurgy and the Cow, by Edward F. Maloney, 50 cents.

51. Everybody Uses Felt. A general description of the origin, structure, evolution, utilization and potentialities of this natural derivative of wool, by Niran Bates Pope, 50 cents.

52. Okra Seed Oil by W. R. Edwards, Jr., and Julian C. Miller, 25 cents.

53. Wood Flour Production by Robert S. Aries, 25 cents.

54. Mesquite Utilization in Texas by E. D. Marshall, 25 cents.

55. Carotene, by R. S. Aries, R. Lester, D. F. Othmer, 25 cents.

56. The Continuous Processes of Wood Distillation, by R. S. Aries, 50 cents.

CASH FOR TIMBER

The market value of the 588,526,000 board feet of timber cut on the National Forests during the three-month period ended March 31 was $2,846,505, an all-time high, the United States Department of Agriculture reports.

The average price paid by bidders for this type of timber rose to the record peak of $4.84 per thousand board feet, the highest average price the Forest Service ever received, and 12 percent higher than for the corresponding quarter of 1946. The first three months of the year is normally a dull season.

Although demand for saw timber is unprecedented, sound forest management on a sustained-yield basis is gaining ground, and 29 percent of the forest-cutting practices on land owned by those holding 50,000 acres or more are now good. But small owners, who hold 76 percent of the privately owned commercial forest land lag in the United States badly.

COTTON

World consumption in present season ending July 31 is pointing toward 27½ million bales, close to 95 percent of prewar (1934-5 to 1938-9) average of about 29 million bales, according to report adopted by International Cotton Advisory Committee at its June session in Washington. Production, after continuing high through most of the war, is down sharply for second successive year, the report stated. "In present season, world crop looks to be less than 21½ million, or not quite 70 percent of prewar average of about 31 million bales," report continued. "Although production is now edging upward, it has not yet given indications of the rebound which many have expected to follow the war's conclusion."

New Riches from the Soil

FIFTH MID-AMERICAN CHEMURGIC CONFERENCE

The Fifth MidAmerican Chemurgic Conference was held in Cincinnati, Ohio, October 1, 2, 3, 1947, at Hotel Gibson.

The sessions were opened by a joint luncheon with the National Retail Farm Equipment Association. L. W. Sidell, president of the latter organization, presided while Wheeler McMillen, president of the National Farm Chemurgic Council, introduced the speaker, John Temple Graves. Mr. Graves is a noted southern newspaper columnist from Birmingham, Alabama. In his talk he emphasized the importance of the farmer's well-being and high standard of living as essential in maintaining our working democracy. The theme of his address was "The Agricultural Pattern", and his comments pointed up the present situation in agriculture, its causes, and what should be done about it.

Mr. B. G. DeWeese, assistant vice president, Union Central Life Insurance Company, Cincinnati, Ohio, opened the Wednesday afternoon session by presenting Dr. W. E. Krauss, at present head of the Department of Dairy Husbandry, The Ohio State University, but who will become associate director of the Ohio Agricultural Experiment Station on January 1. Dr. Krauss outlined the role the college of agriculture and the Ohio Agricultural Experiment Station play in Ohio agriculture. Dr. W. L. Semon, director, Pioneering Research, The B. F. Goodrich Company, Akron, Ohio, devoted his discussion to the "Chemical Upgrading of Agricultural Products". Dr. Semon stated that prosperity of the world depends upon cheap volume production of carbohydrates, fats, and proteins. The value of these products is increased by diversifying their use, and by chemical conversion and upgrading a wider market can be reached. In this way the farmer's profits are increased because his whole crop has greater value.

Wednesday night those attending the Conference were invited to attend the Banquet of the National Retail Farm Equipment Association. An interesting program of entertainment was provided.

Thursday, October 2, the morning session was presided over by Lewis East, Pennsylvania Railroad, Richmond, Indiana. A. L. Galloway, chief in research, Tobacco Byproducts and Chemical Corporation, Inc., Louisville, Kentucky, presented a paper concerning the industrial uses of tobacco. He stated that the United States produced two billion pounds of tobaccos of all types for the manufacture of cigars, cigarets, chewing tobacco, and snuff. Mr. Galloway described the uses of the waste products of the tobacco plant. The stalk is usually returned to the soil by the farmer. Stems and other wastes provide raw material for insecticides containing nicotine. Several other forms of nicotine are used as an anthelmintic for poultry and, in fact, are specifics for the common large round worm. Nicotine is used as a drench for certain internal parasites in sheep and cattle as well as a dip for external parasites on these animals. Nicotine is also used in smoke aerosols for fumigation. Ammonia is recovered in the manufacture of nicotine, and converted to the sulphate and sold for fertilizer purposes. There is also the manufacture of some saucing extracts from the lower grades of tobacco and these are exported for use in flavoring certain types of chewing tobacco. Over 50 compounds have been isolated from tobacco and research is investigating other potential uses.

Dr. Lauren B. Hitchcock, The Quaker Oats Company, Chicago, Illinois, in his address Thursday morning related the history of furfural, its manufacture, and its varied uses. He had on display two exhibits, one illustrating the process by which certain end products, such as nylon hose, were achieved, the other revealed the processing of furfuryl alcohol. Furfural is used in refining lubricating oils, the manufacture of rubber, manufacture of wood rosin, as a resin former, in the manufacture of resinoid grinding wheels, extraction of glyceride oils and as a solvent for many materials such as nitrocellulose and cellulose acetate. There are many other uses for furfural. The greater the demand for this chemical the greater will be the demand for oat hulls, rice hulls, corncobs, and similar residues.

Many products are derived in part or wholly from corn, besides those purely edible products. Some of these surprising applications of corn derivatives were reported by George T. Peckham, Jr., Clinton Industries, Clinton, Iowa. He showed numerous products as an illustration of his talk, and placed them on exhibit later.

The morning session was concluded with an address by Dr. Fred W. Cox, Jr., Southern Research Institute, Birmingham, Alabama, who discussed the winning of new wealth from the soil.

The following session was presided over by J. R. Hartman, vice president of the Cincinnati Gas and Electric Company, Cincinnati, Ohio. James F. Couch, Eastern Regional Research Laboratory, Philadelphia, Pennsylvania, told the story of the discovery of rutin from tobacco and its dramatic medical use for high blood pressure. He reported the research involved in developing more efficient production of rutin and the market it now reaches.

The second speaker was Edwin W. Colt, chief chemist, Armour and Company, Chicago, Illinois, who delivered a paper about developments in the separation of fats and fatty acids. The various ways of separating this material are important in maintaining their production. "Fats and fatty acids are enabling many industries to make better products and to accomplish results not attainable with fats and oils as nature made them," concluded Mr. Colt.

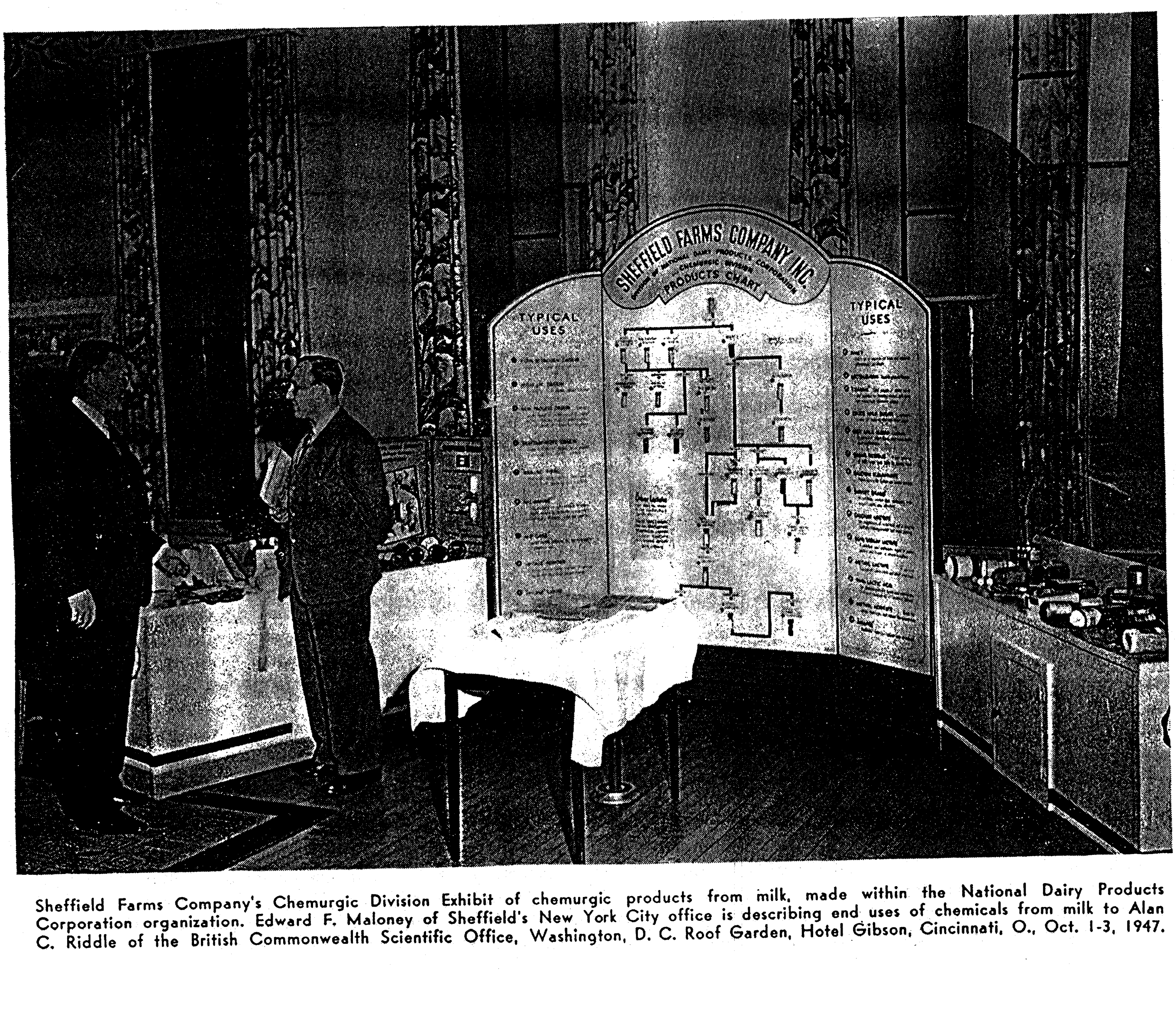
Zein, another corn product, was the subject for discussion by Ray C. Gralow, Corn Products Sales Company, New York, New York. Mr. Gralow reported the history of zein, its manufacture and qualities, and its uses in coatings, printing inks, adhesives and other protein outlets. A number of interesting samples of papers coated with zein products, wood varnished with materials containing zein, and paper printed with ink containing zein illustrated this presentation and were later placed on display.

Dr. Oliver D. Diller, associate forester, Ohio Agricultural Experiment Station, Wooster, Ohio, analyzed the problem of managing hardwood forests for continuous production. The conditions that destroy hardwood forests are fire damage, woodland grazing, over cutting, clear cutting. The first step in proper forest management is solving these problems. He emphasized the need to develop farm woods as a source of sawtimber and veneer logs with pulpwood as a byproduct derived from thinnings and defective trees. Dr. Diller stated that " . . . in general, the most profitable forestry comes from managing the forest for a diversity of products. Ideal harvesting is attained when every tree and portion of tree is cut to make the products that will bring the highest prices and where cutting is done according to a predetermined plan of forest management." Dr. Diller continued that pulpwood production can be increased if pulpwood users and woodland owners worked together to insure a continuous wood supply by following good forest management practices.

Wheeler McMillen, president of the National Farm Chemurgic Council, addressed the chemurgists at the dinner session. He was introduced by Howard Huston, assistant to the president, American Cyanamid Company, New York, New York. Mr. McMillen developed the thought that industrial use of wastes from food crops is the answer to lowering food prices. Chemurgy can aid in lowering the American food bill by making those wastes marketable thereby increasing the income from a crop and lowering its production costs. Mr. McMillen's address was followed by the B. F. Goodrich Company's new film, "Rubber Lends a Hand", which depicts some of the many ways rubber helps the farmer in his work.

On Thursday, Mr. McMillen released an announcement of the formation of a new agricultural and chemical company. This organization, Agratomics Universal, plans to make recent discoveries and products of agricultural chemistry available as quickly as possible to the farmer. Engineers of the new company believe that use of modern chemical methods for weed control and growth stimulation may increase farm production by 60 percent or more. Washington office of Agratomics will be in the Atlantic Building, according to company spokesmen.

The concluding session of the Fifth MidAmerican Chemurgic Conference was opened Friday morning by Dr. Anson P. Hayes, American Rolling Mill Company, Middletown, Ohio. Dr. Paul J. Kolachov, director of research, Joseph E. Seagram and Sons, Inc., Louisville, Kentucky, described the life and industry in Europe



Sheffield Farms Company's Chemurgic Division Exhibit of chemurgic products from milk, made within the National Dairy Products Corporation organization. Edward F. Maloney of Sheffield's New York City office is describing end uses of chemicals from milk to Alan C. Riddle of the British Commonwealth Scientific Office, Washington, D. C. Roof Garden, Hotel Gibson, Cincinnati, O., Oct. 1-3, 1947.

during his visit last August. Frederick J. Triest, Alexander Fries and Bros., Cincinnati, Ohio, discussed "Flavoring Materials from Domestic Crops". He described plants and their uses such as celery and carrot seed, paprika, anise, caraway, fennel, mint leaves, sassafras, wintergreen, fruit flavorings, maple flavoring and many others. "The Availability of Vegetable Tannins" was the topic of Fred O'Flaherty's paper. He presented the urgent need for domestic tannins, the distribution and utilization of the different tannins, and the outlook for future sources of tannin materials. Warren C. Huff, Coke Oven Ammonia Research Bureau, Inc., Columbus, Ohio, then reported the activities of the Joint Committee on Grassland Farming. The purpose of this group is a coordinated research and educational program to secure efficient production of livestock and livestock products. They have prepared a booklet—available at nominal price for distribution—in question and answer form, discussing this subject.

For the first time in several years there were exhibits of chemurgic products displayed at the conference. The Sheffield Farms Company's Chemurgic Division exhibit is pictured on the preceding page.

In addition to the furfural exhibit provided by The Quaker Oats Company, Chicago, Illinois, and others already mentioned, there were the following:

Bureau of Agricultural and Industrial Chemistry, United States Department of Agriculture, showed a comprehensive display of the research achievements of the four regional research laboratories. Fibers from chicken feathers, casein, peanut; textiles from cotton wastes; leather from domestic tannins; and many other items of chemurgic interest.

The Keyes Fibre Company, Waterville, Maine, displayed a variety of paper dishes and plates.

McCormick and Company exhibited mayonnaise, three kinds of prepared mustard, dry mustard, and mustard seed. All these products were made from domestic materials.

Magnus, Mabee and Reynard, Inc., had an exhibit consisting of American distilled essential oils and the botanical source of the oil. Some of these interesting items were garlic oil as well as a pure onion oil. Other items were angelica root oil distilled from American grown roots, pure cedar leaf oil distilled from northern white cedar boughs which grow profusely in the northern parts of Maine, New York, Vermont, New Hampshire, and portions of Canada.

Tobacco Byproducts and Chemical Corporation displayed products made from tobacco, such as various types of insecticides.

Proctor and Gamble Company exhibited products made from soybean and cottonseed oil, edible and industrial. Two large charts served as flow sheets and some of the end products—oils, margarine, livestock feeds, and many others, were displayed on tables.

The Ohio Reclamation Association displayed a number of colored slides depicting the work that is being done in reforesting strip mined areas.

As mentioned previously, several of the speakers displayed material used in their discussions.

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Paper production is still being increased by mills in an effort to cope with the unabated demand. Production ratio is 11.6 percent higher than in 1946, while actual capacity has increased only 5 percent.—Pulp & Paper Bulletin.

Chemurgy Around the World

BRAZIL

Rubber Outlook

Cultivated rubber trees will produce 80,000 kilos of latex this year, according to the Institute of Agronomy for Northern Brazil.

In an optimistic report after two bad years, the Institute predicts that 1948 production will reach 196,000 kilos.

The Institute has set itself a long-range program for improvement of Brazilian rubber trees, especially regarding development of varieties which resist disease. —*Brazilian Bulletin.*

RUSSIA

New Type of Cotton

Collective cotton-growers in Russia plan to sow a new, improved type of Egyptian cotton on a large-scale. The plant is claimed to yield a longer thread and have a higher resistance both to changes of temperature and to pests. Yield is two tons of cotton per hectare.

BRAZIL

Oil Plants Cataloged

The Brazilian Institute for Agricultural Experimentation is preparing a catalog of all oil-producing plants in Brazil. Increase of vegetable oil output is a basic part of the Ministry of Agriculture's four-year plan.

Regional experimental stations have been set up in all regions of Brazil where oil-producing plants either grow wild or are cultivated.—*Brazilian Bulletin.*

SOYA STEROLS RECOVERED IN NEW PLANT

The Glideen Company has completed a new plant in Chicago for the commercial recovery of soya sterols, Paul E. Sprague, Cleveland, Ohio, vice president and assistant to the president, has announced.

Mr. Sprague said that stigamasterol and sitosterol, two important sterols (wax-like alcohols used in making sex hormones and other fine chemicals) has been found in small amounts in the soybean but until now have not been recoverable on a commercial scale. The new Glidden plant, he said, represents the culmination of six years of intensive work by Dr. Percy L. Julian, director of research for the Soya Products Division of The Glidden Company, and his staff.

Believed to be the first commercial operation in the world devoted to recovery of soya sterols by chemical methods, the new plant in all stages of production will employ new processes developed entirely by the Glidden research organization.

Mr. Sprague said the Glidden Company expects to use part of the soya sterols obtained at the plant in the production of fine chemicals. The balance will be offered for sale.—*The Cotton Gin and Oil Mill Press.*

* * *

The products of our forests provide jobs for more than 1,300,000 American workers. (They now earn almost a quarter of a billion dollars monthly).—American Forest Products Industries.

THE STORY OF DIGITALIS

No one knows exactly who introduced digitalis into medicine. Fuchius described the plant in his *Plantarium Omnium Nomenclaturae* in 1541 and assigned to it the present name *Digitalis purpurea.* The synonym, foxglove, was derived from the Anglo-Saxon word "foxesglew", or "fox music"—an allusion to an ancient musical instrument consisting of bells hung on an arched support. As early as the twelfth century A.D., the plant was used medicinally as an external remedy for scrofula. A medical recipe book published in 1644 revealed an additional use of the drug. "Against ye falling sickness (epilepsy) take purple foxgloves, 2 handfuls of the leaves with 4 ounces of polipodium of the oak. Boil them in beer or ale and drink ye decoction." No doubt a decided improvement in the patient's condition was noticed almost immediately.

Concepts of digitalis therapy began with an old woman herb doctor. This woman lived in Shropshire, England, and in 1775 became known for a remarkable remedy that cured dropsy even after accepted methods of treatment failed. Her work soon came to the attention of Dr. William Withering, a learned gentleman, who was both a physician and perhaps the greatest botanist of his day. His interest was aroused, and upon investigating he found that the old woman's decoction contained twenty or more herbs. With his botanical knowledge he quickly perceived that the active ingredient was foxglove.

Dr. Withering began a diligent study of digitalis. He soon discovered that it was a powerful diuretic. Word of the new remedy spread quickly, and shortly after its discovery it became widely and indiscriminately used—frequently fatally. Digitalis was used in the treatment of dropsy, consumption, and fevers and, of course, as a diuretic. Withering continued his work on digitalis in a brilliant and scientific manner until his death in 1799. He recognized its salutary effect on the heart, its toxicity, and its accumulative property. In 1785 he published a monograph on digitalis entitled "An Account of Foxglove and Some of Its Medical Uses, with Practical Remarks on Dropsy and Other Diseases." One reason for writing the book was to curb abuses of digitalis therapy by incompetent enthusiasts. He emphasized that the amount of active material present in the drug was not constant and stressed the importance of controlling the conditions of the plant's growth. He also advised against using the roots and seeds for he had observed great variation in their potency.

A search for the active principle of digitalis was carried out by several chemists during the nineteenth century. One of the best pieces of work was that of Nativelle, who in 1868 isolated a relatively pure principle called "digitaline crystallisee," which possessed all of the pharmacologic properties of the whole leaf. A few years later Schmiedeberg, a German chemist, proved that this substance was 90 percent digitoxin.

Satisfactory therapeutic results with digitalis were not obtained with any degree of regularity until 1898 when E. M. Houghton described a method of bio-assay using the frog as the test animal. Its application served to establish a much greater uniformity of potency of digitalis preparations. Rules with regard to administration of the drug and schedules of dosage could now be formulated. In 1910, Hatcher and Brody further improved the methods of standardization by substituting the cat for the frog as the biological test subject.

Continued chemical and pharmacologic research had demonstrated that digitalis leaf contained saponins, waxes, fats, and other inert materials which did not contribute to the cardiac effects of digitalis but which were responsible for some of the gastro-intestinal irritation. The removal of inactive or otherwise objectionable components gave to the medical profession a product that contained all of the active principles of the whole leaf and one in which the variation in potency was reduced to a minimum.

The active principles of digitalis and of materials obtained from other plants that had a digitalis-like action were found to belong to a class of substances widely distributed in nature. These were called glycosides because, upon hydrolysis, they yielded one or more molecules of sugar and a complex organic compound. If one of the sugar molecules was glucose, the material was known as a glucoside. The organic compounds possessing a cardiac effect were called aglycones, or genins. The sugar itself was shown to be inactive, but its combination with the aglycone rendered the latter more potent. Further studies with regard to chemical structure revealed that a side chain consisting of four or five carbon atoms—a lactone—was the most characteristic part of the molecule and was the one responsible for the typical action of digitalis upon the heart. In 1934 the fundamental structure of the main portion of the aglycone molecule was proved by Elderfield and Jacobs in this country, and simultaneously by other chemists in Europe, to be the same as that of bile acids and sterols. The cardiac aglycones were found to be derivatives of cyclopentenophenanthrene.

The final goal in the chemical investigation of the active principle of digitalis was attained when, in 1933, Stoll was able to isolate three glycosides from *Digitalis lanata,* and when, in 1935, the true glycosides—glycoside purpurea A, glycoside purpurea B, digitoxin, and gitoxin—were isolated from *Digitalis purpurea.* The introduction into the field of clinical medicine of single glycosides which were effective upon oral administration marked the final step in the evolution of digitalis therapy. Since 1940, methods of preparation have improved so that an adequate supply of three glycosides (lanatoside C and digoxin from *Digitalis lanata,* and digitoxin from *Digitalis purpurea*) has become available for extensive clinical investigation in the United States. It had already been shown that the qualitative effect of each of the active principles of digitalis was the same as that of whole-leaf digitalis and that, if a sufficient quantity of any one of these substances reached the heart, it would be capable of producing all of the cardiac effects of digitalis.

The relative efficacy of these materials when given orally, however, depends in large part upon their absorption from the gastro-intestinal tract and upon the rate of elimination from the body. Although it was known that digitoxin was well absorbed, the fact that its absorption was essentially complete was demonstrated in a most striking manner by Dr. Gold and his associates in 1944, when they observed that a given dose of digitoxin produced the *same* change in the ventricular rate of patients with auricular fibrillation in the *same* time, regardless of whether it was given orally or intravenously. Investigators observed that the rate of elimination of digitoxin was the same as that of digitalis leaf. The curves showing the effect upon ventricular rate were so nearly alike when therapeutically comparable doses of standard digitalis and digitoxin were administered that Gold has suggested that the major action of oral digitalis may be attributable to its most absorbable fraction, namely, digitoxin.

Digitoxin is unique among the single glycosides now available for clinical use in that it is both completely absorbed and slowly eliminated. The fact that the amount of lanatoside C required to produce the full therapeutic effect is larger by the oral than by the intravenous route of administration is believed to be due to its poor absorption. Although the amount of digoxin necessary for oral digitalization is also greater than that needed to produce the same therapeutic effect by intravenous administration, the difference in dosage may be attributed to the more rapid elimination of the glycoside rather than to poor absorption. Evidence of the rapid elimination has been obtained by DeGraff and Batterman. This property of digoxin calls for the use of a larger amount to maintain digitalization than is needed if a glycoside having a more prolonged effect, such as digitoxin, is used.

In studies of over a thousand patients it was established by Gold that, by the oral route, 0.1 mg. of digitoxin is therapeutically equal to 0.1 Gm. of U.S.P.XII digitalis. Gold and his colleagues have shown that 1.25 mg. of digitoxin as a single dose will carry the process of digitalization fairly well along in most patients and will produce its full effect within six to ten hours. The use of the single-dose method of digitalization should, of course, be limited to patients who have not received any digitalis for at least three weeks. This quantity of digitoxin may be given as a single dose without nausea and vomiting, because the glycoside is free of irritative materials such as are present in digitalis, and possibly because the actual amount of material administered is so very small. However, as is the case with other digitalis preparations, nausea and vomiting will occur when a quantity of digitoxin is given which exceeds the therapeutic dose. Katz and Wise have suggested that the single-dose method should not be used routinely and that in the majority of instances a schedule of divided doses is preferable.

Digitoxin, as compared with other glycosides (digoxin or lanatoside C), has a more prolonged cardiac effect, which facilitates the maintenance of digitalization. The maintenance dose of 'Crystodigin' (Crystalline Digitoxin, Lilly) is 0.1 to 0.3 mg. per day. In 1928 Hatcher predicted that if a continuous supply of digitoxin could be obtained, it would be used to the exclusion of digitalis. When more clinical evidence has been accumulated, it is not improbable that digitoxin will prove to be the digitalis preparation of choice.

Digitalis was developed through the centuries from an external remedy to an ingredient in a perilously empiric decoction. Upon introduction into recognized medical practice its true therapeutic value came to light. Limited research facilities and knowledge delayed isolation of the active principle for 160 years, and only now is this principle available in large quantities.—*(Reprinted through the courtesy of Tile and Till, Eli Lilly and Company.)*

PEAS WITHOUT MUSTARD

The canner prefers them that way too! Wild mustard weeds commonly infest pea crops. They can never be exterminated, for the seeds can live in soil for fifty years. The weeds come up with the peas and, if they are left to grow, they are harvested and transported with the pea vines at the rate of about one ton of weeds with every two of pea vines, to the viner, the bottleneck of the harvesting capacity, where they impede the process of shelling the peas. And, of course, during their growth they have been competing for plant food and rain and root space, impairing the yields per acre!

Instead of growing and harvesting a crop which may be as much as one-third weeds, recent practice turns to the use of the new selective defoliant chemicals which can be spread on the fields cheaply and easily with dusting machines, to the extent of 75 to 80 pounds per acre, at the suitable moment. This time comes when the mustard has reached the four-leaf stage; its broad leaves, with those of kale and charlock, catch the dust while the thin pea shoots catch little and can stand it; the weeds, with their shallow root systems, die; the pea shoots may yellow and curl, but soon recover and grow to the superior yields which weed-free fields permit, and provide weed-free deliveries to the viners at canning or freezing time. Calcium cyanamide is the active ingredient in the defoliant compound, and its effect on the crop is wholly beneficial. Weed-free fields of peas have always been achievable if enough hand labor was applied, and are necessary if top yields of the order of magnitude of 6,000 pounds of shelled peas per acre are to be secured; the new method used at the proper moment provides a weed-free acre by a simple half-hour's work with a modern duster, at a materials-cost of about $3.00.

Thus does the modern chemist diminish the labors of the man with the hoe!—*For Instance, American Cyanamid Company.*

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